Genetically optimized photonic crystal for spatial filtering of reinjection into broad-area diode lasers

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Modern high-power broad-area semiconductor laser diodes (BASLDs) deliver optical output powers of several ten Watts at high electro-optical conversion efficiencies, which makes them highly relevant for numerous industrial, medical and scientific applications. However, lateral multimode behavior in BASLDs due to thermal lensing turns out highly detrimental, as it results in poor focusability and decreased laser beam brightnesss. Approaches to overcome this issue include improved epitaxial layer design, the optimization of evanescent spatial filtering by tailoring the emitter geometry and facet reflectivity, or Fourier spatially filtered reinjection from an external resonator [1].

Here, we consider the usage of longitudinally chirped photonic crystals (PhC) within the external cavity (EC) [2] for tailoring the spatial filter properties. The corresponding EC setup, consisting of a slow-axis collimating lense, a 2D photonic crystal, and the external mirror (R=4%), is shown in Fig. 1a). While free space propagation in the EC is modeled by Fresnel diffraction integrals, optical propagation through the PhC requires accurate treatment of lateral angular dispersion. For the sake of efficiency of the time-domain BASLD simulator [3], we use a beam propagation method (BPM) based on Rayleigh-Sommerfeld diffraction theory. The chirp of the longitudinal PhC periods is optimized with a genetic algorithm. The transmission amplitude of the optimized structure suppresses lateral propagation angles between 2° and 4°, cf. Fig. 1b), and shows excellent agreement with an exact rigorous coupled wave analysis (RCWA) for calculating PhC transmission and almost vanishing reflection amplitudes. In a next step, we performed numerical simulations of a 1mm long and 100μm broad BASLD subject to PhC spatially filtered reinjection [4]. We found a significant improvement of the lateral far-field profile and increase of beam brightness by a factor 1.5, cf. Fig. 1c). However, for BASLDs with a longer emitter length, lateral waveguide dispersion considerably limits the effectiveness of our scheme.

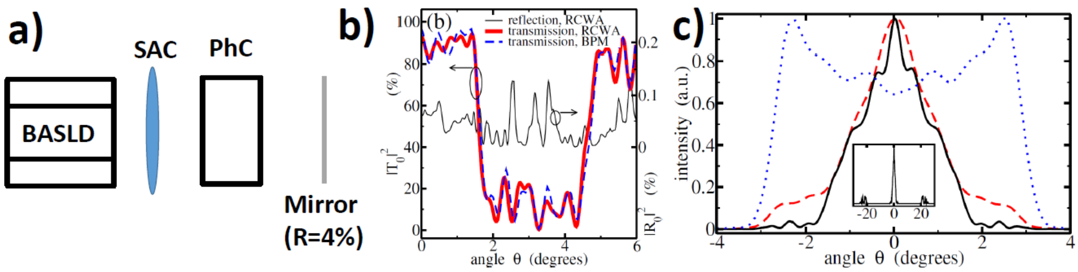

Fig. 1 a) considered setup: BASLD, slow-axis collimating lense (SAC), chirped PhC, external mirror, b) transmission amplitude of chirped optimized PhC, BPM (blue dashed) and RCWA method (red solid), small reflection amplitude (RCWA, black solid) c) spatially filtered emitted far field, (black solid), Fourier transformed near field at diode output facet (red dashed), and far-field of BASLD without optical reinjection (blue dotted)

In summary, we demonstrated theoretically that spatial filtering with photonic crystals is a viable alternative to Fourier slit spatial filtering schemes, and offers increased flexibility for designing tailored angular transmission profiles by suitably optimized longitudinal PhC chirp.

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References

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